Potocatalytic Improvement with Polystyrene Sphere Patterned TiO_2 Films for Environmental Application

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For environmental applications, such as water and air purification utilizing photocatalysts, we synthesized the patterned titanium dioxide (TiO_2) thin films via polystyrene (PS) in this study. This was done, especially for the purpose of enhancing the surface area and photocatalytic properties. The photocatalytic performance was analyzed by UV-visible spectrophotometer. High catalytic efficiency (99% removal) with 20 times faster decomposition rate of malachite green (MG) solution than that of non-patterned TiO_2 was obtained from the patterned TiO_2 with 400 nm size PS due to large surface area. Also, the phenol in water can removed as much as 50% within 2 hours with the same photocalysts, expecting a possible strong candidate for future photocatalysts of water purification.

1. Synthesis of PS pattered TiO_2 film

PS beads of various sizes were arranged on the silicon wafer in order to increase the surface area using 400, 700, 1,000, 1,300 nm in a monolayer coating and the poly styrene (PS) spheres. 200 $\mu\ell$ of TiO_2 sol-gel was dropped onto the PS patterned silicon wafer and allowed to sit for 1 min. Afterward, the PS substrates were coated using the spin coating method (3,000 rpm, 30 sec) and annealed in a furnace at 600 ℃ for 6 hours.

2. Photocatalytic performance measurement

The PS patterned titanium dioxide films were characterized by field emission scanning electron microscopy to evaluate their structures

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The cross-sectional images of figure 1 (e), (f), (g) and (h) show the TiO_2 films-patterned monolayer on the PS spheres mask. The TiO_2 films with 1,000 and 1,300 nm sized patterns had well-ordered honeycomb like structures as shown in Fig. 1 (c), (d). But, the TiO_2 films with 400 and 700 nm sized patterns had disordered structures as shown in Fig. 1 (a), (b). The 400 and 700 nm sized PS spheres had high surface charges. Therefore, smaller PS spheres had more difficulties with aligning in the monolayers than the larger PS spheres.

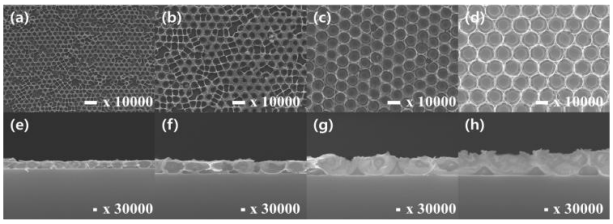

Figure 1. FE-SEM images of top and cross-sectional views of the fabricated structure from the PS patterned TiO_2 films with 400 nm (a), (e), 700 nm (b), (f), 1,000 nm (c), (g) and 1,300 nm (d), (h). Scale bars were 10,000 nm for (a), (b), (c), (d), and 30,000 nm for (e), (f), (g), (h), and respectively.

Figure 2 shows the relative concentration of MG and the C/C_0 over time as the PS patterned TiO_2 films in MG solution were irradiated in UV light for 120 minutes. Within 25 minutes, all PS pattered photocatalysis can decompose the MG solution at least 96% and the MG solution remains less than 0.04 (i.e. 4%). However, the non-patterned TiO_2 film remained 0.38 (i.e. 38%) in the MG solution even when irradiated with an ultraviolet lamp for 120 minutes. Compared to this data, we successfully got higher catalytic efficiency with PS-patterned TiO_2 photocatalysts. Among them, the highest efficiency (99% removal) was obtained from the patterned TiO_2 with 400 nm size PS, due possibly to the large surface area.

Figure 2. Photo-catalytic degradation of MG with non patterned TiO_2 film and patterned TiO_2